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IV. *Some Observations upon Mr. Sutton's Invention to extract the foul and stinking Air from the Well and other Parts of Ships, with Critical Remarks upon the Use of Windsails, by William Watson, F. R. S.*

London, Dec. 4. 1741.

*Read April 1.
1742.*

AS nothing is more conducive to the Health of the human Body, than taking a sufficient Quantity of wholesome Air into the Lungs, so the contrary is attended with pernicious and often with destructive Consequences.

One of the great Uses of Air in Inspiration is, to cool the Blood passing through the Lungs, where Nature has provided, according to the excellent *Malpighius*, that the Blood should be distributed through a vast Number of exceedingly fine Arteries, which are applied all round the thin Vesicles of the Lungs; and by this means the Blood is exposed to the Air under a prodigious large Surface, whereby the Putrefaction is prevented, which, from the *alcalescent* Quality of that Fluid, would otherwise be speedily destructive.

Observations inform us, that contagious Distempers are more frequent in hot Climates than cold; and in closely built Cities fully inhabited, than in Towns: The former may, in some measure, proceed from the too great Heat of the Air, not fully answering the above-mentioned Purposes; and the latter from too many People breathing in the same Atmosphere, thereby rendering it unfit for Respiration.

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It has been frequently tried, that if a Gallon of Air be contained in a Bladder, and by means of a Blow-pipe inspired and expired into the Lungs of a Man, without having any Communication with the external Air; in the Space of a Minute, or little more, it becomes heated, and unfit for Respiration; and without the Addition of fresh Air, the Person would speedily be suffocated. The Diving-bell is another Instance of the same kind, where a constant Supply of fresh Air must be had, to keep out the Water, and refresh the People included.

Although Air is absolutely necessary to our Existence, and Necessity constrains us inevitably to breathe therein, it may be made a Vehicle of most malignant Poisons, as the famous *Grotto del Cani* in *Italy*; poisoning Air by Charcoal, Air impregnated with the Fumes of fermenting vegetable Liquors, stagnant Air, either alone or mixed with Water, soon becomes pernicious, and very offensive; as in Wells dug for Supply of Water, and disused for some time; also in the Wells and in the Holds of Ships, where what is usually called the Bulge-water, if the Ship is tight, and the Water not pumped out often, it soon becomes so extremely poisonous, as frequently to suffocate those Seamen, who, as the Pumps are subject to be clogged with Filth, venture down to cleanse them; and also to affect Persons at a Distance with violent Head-achs, cold Sweats, and frequent Vomiting, which continue more or less, in Proportion to the Distance from the Well of the Ship when the Injury was received, and the Degree of Putrefaction in the Water and Air.

The Air, in Ships particularly, is very liable to be vitiated; not only from the Bulge-water, but from too many People breathing in the same Atmosphere; especially in Ships of War, Hospital-ships, and those used in the *Guinea* Trade for *Negroes*, where a Number of uncleanly People, being stowed too close together, heat the Air, make it replete with noxious *Effluvia*, destroy the Particles therein adapted to cool the Lungs, particularly the acid nitrous *Gas*, which is so abundant in cool Air, and manifests itself not only from the Quantity of nitrous Crystallizations, which may be collected from Caverns of the Earth, especially those open to a Northerly Aspect, but from exposing Pieces of the Flesh of Animals fresh cut, or their Blood, whereby the Colours of their Surfaces are soon changed from a dark deep Red to a more lively and florid one. Air robbed of this valuable Property, and replete with hurtful ones, not only from the People, but from the stinking Water in the Well and lower Parts of the Ship, must produce the most putrid, if not pestilential Fevers.

Although the *Equilibrium* within Places confined is maintained by the external Air, yet unless, by Openings properly adapted, the Air is suffered to pass freely through, the external Air proves as a Stopple to the internal, and only mixes with the next in Contact; as is evident from the common Occurrence in Privies, which are scarcely offensive in clear Weather, but are much so in foul or windy, from a Diminution of the incumbent Pressure, when the Vapours that have been pent up, expand themselves to a considerable Distance.

To prevent the above-mentioned Inconveniencies, and preserve the Healths and Lives of that valuable Part of the Nation, the Seafaring People, many Schemes have been thought of; particularly the Machines of those two very worthy ingenious and industrious Members of this SOCIETY, the Rev. Dr. *Hales*, and the Rev. Dr. *Desaguliers*; the first by an Instrument which he calls *the Ship's Lungs**, and the latter by a Machine†, which is an Improvement of the *Hessian* Bellows: But as these have been laid before the SOCIETY by the Gentlemen themselves, I shall pass them over, and proceed to mention the Contrivance commonly made use of, I mean the Wind-fails. They are made of the common Sail-cloth, and are usually between 25 and 30 Foot long, according to the Size of the Ship, and are of the Form of a Cone ending obtusely: When they are made use of, they are hoisted by Ropes to about Two thirds or more of their Height, with their Basis distended circularly by Hoops, and their Apex hanging downwards in the Hatch-ways of the Ship; above each of these, one of the common Sails is so disposed, that the greatest Part of the Air, rushing against it, is directed into the Wind-fail, and conveyed, as through a Funnel, into the upper Parts of the Body of the Ship. These must be hung up and taken down every time they are used, and the Supply by this Method is not constant. Though Custom has given a Sanction to this Device, it is subject to many Inconveniencies: *1st*, Each Ship having com-

* See Dr. *Hales's* Treatise of Ventilators.

† See these *Transactions*, N^o 437

monly three of these, (one to each Mast) the Seamen are a considerable time in getting their Apparatus ready, and hoisting them up, to make use of. *2dly*, They can only be used in mild Weather. *3dly*, Near the Equator, where fresh Air is most wanted, there sometimes happen such stark Calms, that they are useless by not having Air enough to distend them. *4thly*, The Air hereby admitted passes only into the upper and more open Parts of the Ship, so that the Well, &c. receive no Change therefrom; and it is observed, that sometimes, upon using them after some Discontinuance, they drive offensive Air into the Cabin, and more airy Parts of the Ship; like as the pouring some fresh into stinking Water makes more Water stink, though in a less Degree. *5thly*, They are improper to be used in the Night-time, when the People are sleeping between Decks. And, *Lastly*, admitting they had none of the former Inconveniencies, their Use must be destructive in Hospital ships; where, though fresh Air imperceptibly received is absolutely necessary to preserve the Crew as free as possible from the infectious Breath and Exhalations of the diseased and wounded Seamen, yet Blasts of Wind, pouring impetuously into the very Places where the Sick lie, must be attended with such Consequences as are too obvious to mention.

To remedy these Inconveniencies, to prevent Air proving foul even in the Wells and Holds of Ships, and to cause imperceptibly a large Circulation of fresh Air into every Part of the Ship at all times, Mr. *Sutton* has invented the following Scheme *, which is

* See these *Transactions*, N^o 462. p. 42.

useful not only in these Cases, but, by altering some Parts, as particular Places require, may be applied to Houses, close Parts of Prisons, Wells at Land, Privies, Hospitals, &c.

Nothing rarefies Air so considerably as Heat, and whenever it causes a Diminution of the Density of the Air, that Part next in Contact will rush in, and be succeeded by a constant Supply, till the Air becomes of an equal Degree of Elasticity. Therefore, if a Tube be laid in the Well, Hold, or any other Part of the Ship, and the upper Part of this Tube be sufficiently heated to rarefy the impending Column of Air, the *Equilibrium* will be maintained by the putrid Air from the Bottom, which being drawn out this way, a Supply of fresh Air from the other Parts of the Ship will succeed in its Place; which Operation, being continued, will intirely change the Air in all the Parts of the Ship. This Principle, exactly conformable to the Doctrine of Pneumatics, is the Basis of Mr. *Sutton's* Machine, which being put in Execution on board the *Hulk* at *Deptford*, before the Lords of the Admiralty, Commissioners of the Navy, our very learned and ingenious President *M. Folkes*, Esq; Dr. *Mead*, &c. performed to their Satisfaction, in bringing Air from the Bread-room, Horlop and Well of the Ship at the same time, in such Quantity, that large lighted Candles being put to the End of Tubes, the Flame was immediately sucked out as fast as applied, though the End of one of the Tubes was above Twenty Yards distant from the Fire. The Method is as follows:

To boil the Provisions of the Ship's Company, they must have a Copper which is bigger or less, in pro-

portion to the Size of the Ship, and Number of the Crew : This Copper is fixed in Ships in the Manner as on Land, having under it Two Holes divided by an iron Grate. The first Hole, having an iron Door, is for the Fire ; the Ashes from the Grate drop through into the Bottom of the other; the Smoke passes through a Chimney, and is discharged as usual. After the Fire is lighted, it is supported by the Air from the Parts next the Ash-pit ; but having, contrary to the usual Custom, adapted an iron Door, like the former, made very tight, to prevent the Ingress of Air, the Fire would soon be extinguished, if not supplied by some other Aperture ; in order to which, one or more Holes are made through the Brick-work in the Side of the Ash-pit ; and Tubes of Lead or Copper, fitted closely in the Holes, and made fast, are laid from thence into the Well, and other Parts of the Ship ; by which means the Air next the Bottom of the Tubes rushes through them, and the foul and stinking Air succeeding is transmitted through the Fire, and passes off, without offending, by means of the Chimney ; and a Supply of fresh Air from the other Parts of the Ship continually fills the Place of the former, the Fire requiring a constant Support, which Support will be wanting, not only during the Continuance of the Fire, but while any Warmth remains in the Fire-place, Copper, or Brick-work, as was observed on board the *Hulk* at *Deptford*, where the Draught of Air through the Tube lasted above Twelve Hours after the Fire was taken away. This being considered, as the dressing the Provisions for a Number of People will take up some Hours every Day, the Warmth of the Brick-work and Flues will
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continue a Draught of Air from one Day to the next. Mr. *Sutton* proposes thus to circulate the Air by the same and no greater Expence of Fire than is customarily used for the Necessities of the Ship. The Operation of the Machine will be equally useful in large as small Ships; for the greater the Number of People they have on board, the larger Quantity, and longer Continuance, of the Fire will be necessary to dress the Provision; and therefore there will be required a greater Quantity of Air to support that Fire. The Size and Number of the Tubes need not be specified, because as the Consumption of Air is in proportion to the Quantity of Fire, the wider the Tube, and greater the Number, the less the Velocity of the Air, and *vice versa*.

I several times observed in this Machine, when for the sake of Observation, after the Fire was well lighted, and the lowest iron Door left open, that the Flame did not ascend so high, or burn so fierce; but immediately upon shutting thereof, when the Draught of Air was only through the Tubes, the Flame soon recovered its former Vigour.

There is likewise, especially in large Ships, not only a Copper, but also a Fire-grate like those used in Kitchens: That the Heat and Smoke of this also may not be useless, an iron Tube may be fixed behind the Grate, and inserted quite through the Brick-work, and through the Deck, so that one End thereof will stand about a Foot, or little more, in the Chimney above the Brick-work, and the other will enter into the Hold, or any other Part of the Ship; so that the upper End being heated, the Draught of Air will be supplied from below, as in the other Case. This
like-

likewise was tried on board the *Hulk*, with an iron Tube about Two Inches and an half in Diameter, and the lighted Candles held at the Bottom of this Tube were extinguished as fast as by any of the other.

It may be objected, that a Number of Tubes take up too much Room, especially in Merchants Ships, and are subject to be broken or injured by loading or unloading: To remedy which, it is adviseable, that only one Tube of a convenient Size be made fast unto the Side of the Ash-pit, and, as soon as it comes through the main Deck, to compress it (a circular or any other Form being equally useful) not too close; and it may be divided into as many Ramifications as may be thought necessary, (especially as the Bread-room, Store-room, &c. cannot be kept too sweet, a Branch for each of these) and these Branches be carried between the Beams which support the Deck, till they come to the Side of the Ship, and there let down likewise between the Beams into the Places intended; by which Contrivance their Operation will not in the least be obstructed, and the Tubes be secured from any Accident.

The Simplicity of this Machine, it being so little cumbersome, its Operation without any Labour to the Seamen, the small Expence to put it in Execution, and maintain it, besides the before-mentioned Considerations, are other Arguments for its general Use.